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CHEMICAL ENGINEERING REFRESHER PROGRAM

ANALYTICAL CHEMISTRY, BIOCHEMICAL ENGINEERING AND MATERIALS SCIENCE

1. Find the pH of a 0.0025 M HCl solution. Express the answer to the correct number of significant figures.
   - a. 2.6
   - b. 2.601
   - c. 2.602
   - d. 2.6021

2. Refers to the component of interest in a sample solution.
   - a. Aliquot
   - b. Analyte
   - c. Matrix
   - d. Sampling

3. Determine the volume in millilitres of one mole of pure ethyl alcohol.
   - a. 10 Ml
   - b. 58 mL
   - c. 46 Ml
   - d. 78 Ml

4. What weight of magnesite should be taken for analysis in order that, after converting all the Fe to a precipitate of $Fe_2O_3 \cdot xH_2O$, the percentage of Fe_3O_4 in the sample can be found by multiplying the weight of the ignited precipitate in grams by 100?
   - a. 0.9666 g
   - b. 1.0478 g
   - c. 1.3719 g
   - d. 1.8007 g

5. Most metals are analyzed using EDTA in a _____ solution.
   - a. Weakly acidic
   - b. Strongly acidic
   - c. Weakly basic
   - d. Strongly basic

6. Technical grade concentration of concentrated sulfuric acid is
   - a. 18 M
   - b. 12 M
   - c. 15 M
   - d. 17 M

7. A 500-mg sample containing NaCN required 23.50 mL of 0.1255 M AgNO3 to obtain a permanent faint turbidity. Express the result of this analysis as % CN-.

   Titration reaction: $2CN^{-1} + Ag^+ \rightarrow Ag(CN)_2^{-1}$

   Endpoint reaction: $Ag(CN)_2^{-1} + Ag^+ \rightarrow Ag[Ag(CN)_2](s)$
   - a. 15.34%
   - b. 23.01%
   - c. 17.25%
   - d. 30.67%

8. HCl reacts with $Ba(OH)_2$ to give water and $BaCL_2$. If 25.00 mL of an HCl solution reacts with 25.00 mL of a 0.2000 M $Ba(OH)_2$, what is the molarity of the HCl solution?
    a. 0.2000 M
    b. 0.4000 M
    c. 0.6000 M
    d. 0.8000 M

9. A 2L sample of mineral water was titrated with EDTA to determine its hardness in terms of ppm $CaCO_3$. The EDTA solution was titrated using 247 mg of primary standard $CaCO_3$ requiring 27.8 mL for titration to the Calmagite endpoint. A 50-mL aliquot was titrated with 34.7 mL EDTA. Determine the hardness of the sample.
    a. 3614
    b. 4382
    c. 5973
    d. 6166

10. A 212.2 mg sample of an organic compound is burned in a stream of oxygen and the CO_2 produced was collected in a solution of barium hydroxide. Calculate the percentage of carbon in the sample if 600 mg of $BaCO_3$ (197.35) was formed.
    a. 17.20%
    b. 25.80%
    c. 34.40%
    d. 51.60%

11. A 0.0722 M of weak monoprotic acid has pH of 3.15, what is the pKa of the acid?
    a. 4.93
    b. 5.15
    c. 6.37
    d. 7.02

12. The phosphorus in a 0.2385-gram sample was precipitated as the slightly soluble $(NH4)3PO4*12MoO3$. The precipitate was filtered, washed and then redissolved in acid. Treatment of the resulting solution with an excess of Pb^{2+} resulted in the formation of 1.6725 gram of $PbMoO_4$. Express the results of the analysis in terms of % P_2O_5. Molar masses: $PbMoO_4$ (367.14) and P_2O_5 (141.94)
    a. 11.29%
    b. 20.23%
    c. 39.67%
    d. 51.02%

13. What is the pH of a saturated solution of magnesium hydroxide, $Ksp = 1.8 \times 10^{-11}$ in a solution that is 0.2 M with respect to Mg^{2+}?
    a. 8.68
    b. 8.98
    c. 10.22
    d. 10.52

14. Which of the following could best lessen cost but still get accurate results during standardization process?
    a. Lessen the mass of primary standard used during titration
    b. Dissolve minimum amount of sample to be used during titration
    c. Get aliquot portion of the solution containing the sample
    d. All of these

15. In which type of chromatograph is the interaction between the analyte and the stationary phase due to the size of the molecule only?
    a. Adsorption chromatography
    b. Gel permeation chromatography
    c. Partition chromatography
    d. Affinity chromatography

16. How long will it take to deposit all the copper in 100 mL of 0.250 M Cu^{2+} solution using a current of 1.20 A?
    a. 1005 sec
    b. 2010 sec
    c. 4020 sec
    d. 8040 sec

17. In a voltammetric analysis, 50.0 mL of analyte solution were diluted to 100.0 mL and gave a peak current of 2.50 mA. A second sample was prepared by taking 50.0 mL of the analyte solution and 10.0 mL of 0.0500 M standard, diluting to a final volume of 100.0 mL. The diluted solution gave a peak current of 3.00 mA. The concentration of the analyte is:
    a. 0.0249 M
    b. 0.249 M
    c. 0.0498 M
    d. 0.498 M

18. Calculate the absolute standard deviations of the results of the following calculations:
    $y = \log[2.00(\pm 0.02) \times 10^{-4}] = -3.6990 \pm$ _____
    a. 0.01
    b. 0.004
    c. 0.02
    d. 0.434

19. If a sample transmits 75% of the incident light, it has an absorbance of:
    a. 0.125
    b. 1.88
    c. -0.125
    d. -1.88

20. A sample in a 1.0 mm cell transmits 75.0% of the incident light at 510 nm. If the solution is 0.075 M, its molar absorptivity (M-1 cm-1) is:
    a. 1.0 x 10-4
    b. 1.67
    c. 16.7
    d. 167

21. In a Lineweaver-Burk plot, the slope is _____.
    a. -Km/Vmax
    b. Km/Vmax
    c. Vmax/Km
    d. 1/Vmax

22. Which phase has the condition of specific growth rate "$\mu = 0$"?
    a. Lag Phase
    b. Log Phase
    c. Stationary Phase
    d. Death Phase

23. Complex carbohydrates which make up cell wall in plants are?
    a. Lactose
    b. Fructose
    c. Celluose
    d. Sucrose

24. Which enzyme was first produced industrially?
    a. Apatite
    b. Barytes
    c. Dolomite
    d. Hornblende

25. If one starts with 10,000 (10^4) cells in a culture that has a generation time of 2 h, how many cells will be in the culture after 4 and 48 h?
    a. 4.0×10^4 cells, 1.7×10^11 cells
    b. 4.2×10^4 cells, 1.1×10^11 cells
    c. 4.6×10^4 cells, 1.5×10^11 cells
    d. 4.8×10^4 cells, 1.3×10^11 cells

26. Name the phase which is a period of adaptation of the cells to the new environment.
    a. Lag Phase
    b. Log Phase
    c. Stationary Phase
    d. Exponential Phase

27. Which of the following is used to grow bacterial cultures continuously?
    a. Haemostat
    b. Chemostat
    c. Bacteria cannot be grown in continuous culture
    d. Thermostat

28. Laboratory studies have shown that microorganisms produce 10 mg/L of biomass in reducing the concentration of a pollutant by 50 mg/L. Calculate the yield coefficient.
    a. 0.2 mg biomass/mg substrate
    b. 5.0 mg biomass/mg substrate
    c. 0.4 mg biomass/mg substrate
    d. 10 mg biomass/mg substrate

29. Yeast cells grew from 19 to 54 kg dry cell m−3 in 7 h. During this period 81 g of glycerol was consumed per 1 L of the fermentation broth. Determine the average specific growth rate and the cell yield with respect to glycerol.
    a. 0.15 h^-1, 0.43 kg dry cells formed/kg substrate consumed
    b. 0.31 h^-1, 0.65 kg dry cells formed/kg substrate consumed
    c. 0.45 h^-1, 0.79 kg dry cells formed/kg substrate consumed
    d. 0.70 h^-1, 0.92 kg dry cells formed/kg substrate consumed

30. Escherichia coli grows with a doubling time of 0.5 h in the exponential growth phase. What is the value of the specific growth rate?
    a. 0.45 h^-1
    b. 0.67 h^-1
    c. 0.98 h^-1
    d. 1.39 h^-1

31. Compute the number-average molecular weight for a polystyrene for which the degree of polymerization is 25,000.
    a. 2.60 X 10^6 g/mol
    b. 4.52 X 10^6 g/mol
    c. 7.82 X 10^6 g/mol
    d. 8.80 X 10^6 g/mol

32. The wavelength used in a particular X-ray diffraction analysis is 1.539 Angstrom. If an intense peak occurs at a 2-theta value of 44.28 deg, what is the d-spacing (angstrom) in this structure? Assume first order.
    a. 0.045
    b. 1.342
    c. 2.042
    d. 4.489

33. When the D-line of sodium light impringes an air-diamond interface at an angle of incidence of 30.0 deg, the angle of refraction is 11.9 deg. What is the nD for diamond?
    a. 1.34
    b. 2.42
    c. 3.980
    d. 5.021

34. Calculate the number of atoms per cubic meter in aluminum. Aluminum: density = 2.71 g/cm3 ; A = 26.98 g/mol
    a. 6.05 x 10^28 atoms/m3
    b. 8.90 x 10^28 atoms/m3
    c. 10.52 x 10^28 atoms/m3
    d. 15.20 x 10^28 atoms/m3

35. What is the composition, in atom percent, of an alloy that contains 99.7 lbm copper, 102 lbm zinc, and 2.1 lbm lead?
    a. 40.3 at% Cu, 49.7 at% Zn, 10 at% Zn
    b. 47 at% Cu, 49.7 at% Zn, 3.3 at% Zn
    c. 45 at% Cu, 45 at% Zn, 10 at% Zn
    d. 50 at% Cu, 49.7 at% Zn, 0.3 at% Zn

36. Zirconium has an HCP crystal structure and a density of 6.51 g/cm3. What is the volume of its unit cell in cubic meters?
    a. 0.296 x 10^-28
    b. 1.002 x 10^-28
    c. 1.396 x 10^-28
    d. 2.412 x 10^-28

37. Iron has a BCC crystal structure, an atomic radius of 0.124 nm, and an atomic weight of 55.85 g/mol. Determine the density in g/cm3.
    a. 2.20
    b. 4.65
    c. 7.90
    d. 10.23

38. If the atomic radius of aluminum is 0.143 nm, calculate the volume of its unit cell in cubic meters.
    a. 6.62 x 10^-29 m3
    b. 8.56 x 10^-29 m3
    c. 1.05 x 10^-28 m3
    d. 1.26 x 10^-28 m3

39. Some hypothetical metal has the simple cubic crystal structure. If its atomic weight is 70.4 g/mol and the atomic radius is 0.126 nm, compute its density in g/cm3.
    a. 4.32
    b. 7.31
    c. 10.32
    d. 15.60

40. Rhenium has an HCP crystal structure, an atomic radius of 0.137 nm, and a c/a ratio of 1.615. Compute the volume of the unit cell for Re.
    a. 8.63 x 10^-23 cm3
    b. 1.02 x 10^-22 cm3
    c. 1.32 x 10^-23 cm3
    d. 1.54 x 10^-23 cm3